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# INFLUENCE OF THE CHARACTERISTICS OF BULK MATERIALS ON THE DESIGN OF BUCKET-WHEEL RECLAIMERS

## 1 - REFERENCES

This document forms part of document FEM 2 581 "Characteristics of bulk products" and refers to document FEM 2 582 "General characteristics of bulk products with regard to their classification and to their symbolization".

## 2 - OBJECT AND PURPOSE OF THIS DOCUMENT

The aim of this document is to describe the relationship between the characteristics of the bulk materials to be conveyed and the design of bucket-wheel reclaimers operating on material stockpiles. It should be stressed however that this document does not cover excavator type appliances.

Bucket-wheel reclaimers appliances are complex machines, including generally, among other mechanisms, a reclaiming unit, essentially consisting in a bucket-wheel which feed a belt conveyor.

This document considers the influence of bulk material characteristics on the bucket-wheel reclaiming unit itself.

Concerning conveyor(s) reference can be made to document FEM 2 124 which covers the influence of the characteristics of bulk materials on the design of belt conveyors. It should then be noted that the type and technical characteristics selected for the bucket-wheel and the operating method of the appliance are also criteria for selecting the components of the conveyor(s), especially the belt width and belt speed which must comply with the instantaneous flowrate peaks of the bucket-wheel.

## 3 - GENERAL

The characteristics of the bulk material to be reclaimed by a bucket-wheel reclaimer together with the quantity of material to be reclaimed in a given time influence the design and characteristics of the bucket-wheel. It is therefore necessary that the user shall disclose to the bucket-wheel manufacturer all the relevant information about the material to be handled of which he is aware, and that he shall also point out any items of information he suspects may be relevant, the effects of which are not within the scope of his knowledge.

Material reclaiming is carried out through regular rotation of the bucket-wheel associated with a simultaneous transversal motion, the buckets being filled in the lower part of their travel (while they dig into the stockpile) and then releasing the reclaimed material in the upper part of their rotation path.

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The bucket-wheel plane may be vertical or, if possible, slightly inclined in comparison with the vertical in order to facilitate material unloading towards the receiving centering device.

The characteristics of the materials to be reclaimed and the wanted reclaiming capacity are essential elements in the design of the bucket-wheel itself, since they govern in particular the following characteristics :

- selection of bucket-wheel type (cell or cell-less type, ...),
- dimensions, number and shape of buckets,
- wheel rotation speed, hence tangential speed of bucket penetration into the material,
- layout of cutting parts (bucket penetrating edges, claws, ...),
- digging efforts, hence drive power required on the reclaiming unit,
- slope of receiving centering devices (in order to achieve correct material flow),
- antiadhesive (e.g. chain mesh mat in buckets) or antiwear devices (abrasion-proof linings),
- ...

## 4 - INFLUENCE OF THE CHARACTERISTICS OF BULK MATERIALS

The following text deals in turn with the individual characteristics of the bulk materials used in FEM 2 582 for classifying the bulk materials, in the sequence laid down there, with reference to their effects on the design of bucket-wheels.

### 4.1 - Name of the bulk material

The name of the bulk material to be reclaimed and handled can serve the specialist as an indication of the properties of the bulk material, particularly if he can call on earlier experience of conveying this bulk material with a bucket-wheel reclaimer. But the name of the bulk material often does not suffice to give a precise description of the bulk material, since bulk materials with the same name can have highly different properties which are also determined by the origin of the bulk material, as well as by previous processing, conveying, storage processes, ...

The name of the bulk material gives a first indication for selecting the appropriate speed of bucket penetration into the bulk material (i.e. tangential speed) hence, according to the bucket-wheel diameter, of its rotation speed. Of course, wheel rotation speed will also be selected on the basis of characteristics of the material such as, in particular, grain size (see section 4.2), abrasiveness (section 4.6), mechanical sensitivity (section 4.8) and bulk density (section 4.17).

Although it is not intended to give too limited an indication, it can be noted however that in the state of the art the most common rotation speeds for bucket-wheels range from 5 to 10 r.p.m., the lowest speeds being used for large grain materials with high bulk density, e.g. abrasive run-of-mine iron ore materials.

With less dense, fine and little abrasive materials, higher speeds are used which can then be limited, not by the bucket penetration speed into the material, but by the time necessary for a correct emptying of the buckets.

The name of the bulk material gives also an indication for estimating the specific penetration coefficient k of buckets into the material (see section 4.2).

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## 4.2 - Grain size

Knowledge of the maximum grain size is necessary to determine the dimensions of wheel buckets.

The smallest bucket width at right angle with the material to be reclaimed, as well as the smallest dimension of flow cross sections must in general be at least 2.5-3 times the maximum dimension of the largest lump, the lowest ratio applying only to materials with a small percentage of large lumps regularly distributed in the material mass. Care should be taken with materials which, as a result of the storing process for instance, can be subjected to segregation effects, in which case the bucket-wheel has to operate temporarily (when it operates at the base of the stockpile for example) in a material with a large lump content much higher than its average content.

Knowledge of the complete grain size analysis of the bulk material is also useful to determine the specific penetration coefficient k (in N/mm or kN/m) of buckets into the material.

Specialized literature gives indications on the values of this coefficient k, and a few reference values are given below for bulk materials currently handled by bucket-wheel reclaimers.

| Values of k in N/mm=kN/m | |
|---|---|
| - coal ... ..... | 8 to 30 |
| - limestone ..... | 10 to 25 |
| - coke ..... | 8 to 35 |
| - sand ..... | 5 to 20 |
| - slag ..... | 5 to 25 |
| - ore ..... | 10 to 80 |

The specific penetration coefficient k is mainly influenced by the grain size and grain shape of the material but it is also influenced by the bulk density and the cohesion of the material.

## 4.3 - Grain shape

Grain shape for material with a large grain size must be taken into account when selecting the minimum width of buckets and flow cross sections. Wedging risks are in relation with the grain shape.

Grain shape also affects the value of the specific penetration coefficient k : for instance, a material which contains irregular lumps with sharp edges will be highly resistant to bucket edge penetration, as opposed to a material formed of spheric and sleek grains (e.g. pellets).

## 4.4 - Angle of repose $\alpha$

The angle of repose $\alpha$, as per FEM 2 582, can be used as a sufficient reference value to estimate the coefficient of internal friction $\mu$ of the bulk material in the bucket wheel with $\mu \simeq \tan \alpha$ ; this particular formula only applies to bulk materials with a negligible cohesion.

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